

## **Appendix J: Hydrology And Water Quality**

### **General Concepts**

Mean annual precipitation in the study area ranges from 40 inches near Lake Washington to almost 60 inches in the headwaters of May and Coal Creeks. Storms are typically long-duration, low-intensity events that produce fairly uniform precipitation throughout the region. Most of the precipitation falls as rain. Rainfall is greater than potential evapotranspiration from October through April.

Soils and vegetation reflect the region's glacial history, and have a strong influence on how runoff is produced. In forested areas about half of annual precipitation is lost to interception and evapotranspiration (Dinicola, 2001). Rainfall intensities are usually less than infiltration rates, and overland flow is rare except where groundwater saturates the soil column. On hill slopes covered by glacial till most runoff flows beneath the surface, on top of the hardpan layer. In depressions and stream bottoms the groundwater table rises to the surface during storms, creating saturated zones that produce rapid overland flow. Little runoff is produced on glacial terraces because of the high permeability of outwash deposits. Runoff from adjacent hill slopes will often infiltrate into the terrace outwash soils and recharge groundwater.

Land disturbance and development compact soils and reduce infiltration rates. Most of the runoff from lawns occurs as overland and shallow subsurface flow. Pavement and rooftops are virtually impervious, and produce rapid overland runoff. Along the I-405 corridor paved areas generate an average of 33 inches of annual runoff, compared to only 7 inches from forested till soils (based on results from WSDOT's MGSFLOOD model). During a 100-year flood paved areas generate over 390 cfs/square mile, whereas forested till soils generate only 50 cfs/square mile. Newer developments use Best Management Practices to mitigate these impacts. However, most of the urban areas in the study area predate modern stormwater regulations, and have few stormwater detention or treatment facilities.

### **Regional Hydrogeology**

Glaciers covered much of the region until about 15,000 years ago. As the glacial ice advanced, it reworked and compacted the underlying soil and rocks. Water melted from the leading edge of the glaciers, forming large channels that carried sands and gravels downstream. When the glaciers receded, they left behind thick layers of material that cover most of the landscape. The one exception is the Newport Hills in the headwaters of Coal and May Creek, where uplifted marine sedimentary and volcanic rocks rose above the surrounding glaciers.

Figure 8 in the main body of the document depicts the surficial geology within the study area. Much of the glacial material was deposited onto gently sloping plains. The top layer in these areas is glacial till, made up of silts, clays, and scattered rocks that have been compressed by ice. Till is very dense and almost impermeable to water. Soils on till often have a layer of hardpan at about 3-feet depth.

Outwash deposits are found in old glacial meltwater channels, and are made up of coarse sands, gravels, and cobbles. Advance outwash (deposited as the glaciers advanced) often lies below glacial till. Recessional outwash (deposited as the glaciers receded) lies on top of glacial till, and is usually found in terraces along the margins of stream valleys.

Modern streams eroded through the glacial deposits, and deposited new materials in the stream valleys. Flat streams (such as May Valley) deposit fine silts and wetland soils on top of recessional outwash. Steeper portions of May and Coal Creek carve ravines into the glacial material, and intercept groundwater in advance outwash deposits. The Cedar River has cut a broad valley and steep bluffs into the glacial plains. The modern floodplain has eroded into the original valley floor, leaving behind terraces of recessional outwash on the valley margins.

Water that does not runoff or evaporate infiltrates into the soil, where it may recharge groundwater. Groundwater recharge seeps vertically through glacial till until it reaches coarser material (generally advance outwash or other fluvial deposits). Water moves more rapidly through the coarse material, and flows downslope towards stream valleys and Lake Washington.

Coarse river deposits have formed an alluvial fan at the mouth of the Cedar. This alluvial fan is now the most productive aquifer in the area, providing over 6.5 million gallons per day for the City of Renton (City of Renton, 2003). The water table lies within 23 feet of the ground surface in some areas, and is closely related to water levels in the Cedar River. The Cedar River aquifer is a sole source aquifer, and the City of Renton has designated special aquifer protection zones to protect water quality in this important resource (Figure 9 in the main body of the document shows the Aquifer Protection Zones). Zone 1 covers the area near the city's wells, and has the highest level of protection. Infiltration of stormwater is prohibited, and all stormwater conveyance, detention, and water quality facilities must be lined. Infiltration facilities are allowed in Zone 1 Modified and Zone 2, but stormwater must be treated for water quality prior to infiltration. All areas subject to vehicular use or chemical storage must be covered with impervious surfaces.

Advance outwash deposits often contain groundwater that is partially confined by till. This groundwater is an important water source for wetlands and streams that intercept advance outwash deposits. Advance outwash may provide large yields to wells, but its distribution is erratic in the study area (Liesch et al., 1963). Small lenses of groundwater may also be found in till deposits, and are occasionally tapped for small domestic wells in rural areas.

Although till covers most of the area, groundwater recharge is most rapid where coarse recessional outwash is exposed at the surface. Relationships developed by Vaccaro et al. (1998) show that outwash provides about 24 inches per year of recharge, compared to only 16 inches for till-covered areas. Recharge rates are even lower in developed areas where pavement and soil compaction have reduced soil infiltration rates. In the Cedar River basin development has decreased groundwater recharge rates by 5-10 percent (Metropolitan King County Council, 1997).

## **Coal Creek**

Coal Creek drains 4,220 acres of land that extends from the slopes of Cougar Mountain down to the shores of Lake Washington (Figure 10 in the main body of the document shows Drainage Basins And Soils). I-405 crosses the stream about 1-mile upstream of the mouth. Newport Creek is the largest tributary, and enters Coal Creek just upstream of I-405. Over 95 percent of the basin area is underlain by Alderwood till soils with high runoff potential. Most of the land downstream of I-405 is covered by fine delta deposits.

Coal Creek drops rapidly through sequences of bedrock, till, and advance outwash. Historical coal mining has radically altered surface water/groundwater interactions in the upper watershed.

The headwaters of the South Fork tributary originates from a caved-in mine adit, which serves as an outlet for an extensive mine drainage system (City of Bellevue and King County, 1987). In the lower section of the valley the creek intercepts and is probably fed by groundwater contained in advance outwash.

The Coal Creek basin has developed rapidly since the 1980s. In 1983 more than 70 percent of the basin was covered with deciduous or coniferous forest. The latest King County land cover data show less than 40 percent of the basin remaining as forest. Urban land uses cover 45 percent of the basin. The remaining forest cover is concentrated in parklands in the upper watershed and along the creek canyon in the lower watershed. The total impervious area for the basin is about 21 percent.

Table J-1 lists peak flow estimates for Coal Creek near I-405. Between 80 and 90 percent of the peak flow at I-405 is generated above Coal Creek Parkway, where steep slopes, thin till soils, and high precipitation combine to produce high runoff rates. This is also the most rapidly developing portion of the watershed. At Newcastle Road the creek drains areas protected by Cougar Mountain Regional Park, and peak flows are about 20 to 30 percent of the peak flow at I-405.

Sediment control is the priority stormwater issue in the basin. Because of the limited opportunities for detention and sedimentation ponds, existing facilities trap only a small percentage of the annual sediment load. Local governments are therefore focusing their efforts on channel stabilization and bioengineering of steep slopes. Mine tailing slopes have been a challenge to stabilize because the loose soils provide poor conditions for bioengineering.

Most of the lower portion of Coal Creek lies within the City of Bellevue, which partnered with King County to develop the Coal Creek Basin Plan in 1986. The City of Bellevue implemented many of the recommendations from this plan, including stabilization of stream channels, rerouting of stormwater outfalls, and construction of detention and sedimentation ponds at Coal Creek Parkway and I-405. Both of these detention ponds were constructed as instream facilities, and use the road embankments to impound water. The designs predate modern stormwater requirements, and are therefore undersized by current standards.

The plan also proposed building detention ponds in the Newport Hills and at the cinder mine; however, these were not constructed. Because the Newport Hills site presents problems to adjacent land uses, it is no longer considered as a viable project (Rick Watson, City of Bellevue, personal communication). The cinder mine site is still viable despite problematic soil conditions.

The City of Newcastle was incorporated after the basin plan was developed. Less than 20 percent of Newcastle drains into the Coal Creek basin. The city operates no major stormwater treatment facilities in the basin, although there are facilities that serve private developments.

The Newcastle Hills golf course straddles the May Creek – Coal Creek divide, with most of the area flowing into Coal Creek. During construction there were numerous problems with sediment and erosion control, resulting in large sediment loads into Coal Creek and Lake Boren. The site has now been stabilized.

### **May Creek**

The May Creek basin drains 8,950 acres, and extends from the Newcastle Hills (maximum elevation 1,600 feet) down to near sea level at Lake Washington. Alderwood till soils cover the majority of the upland areas, and make up over 80 percent of the total basin area. Everett and

Ragnar outwash soils are found in May Valley and on terraces along the lower creek canyon. Indianola loamy fine sands occur on recessional outwash in the southwestern portion of the basin.

The headwaters of May Creek originate in the Newcastle Hills, but quickly drop down into May Valley near SR 900. This low-gradient valley was once part of a glacial outwash channel that connected with McDonald Creek to carry meltwater from glaciers in the Snoqualmie and Skykomish valleys. A natural rock sill near 148<sup>th</sup> Avenue SE controls the gradient of the valley, which filled in with wetland deposits and alluvium after the glaciers receded. During the winter groundwater collects in May Valley, and combines with stream runoff to feed extensive wetlands and lowland flooding. Below 148<sup>th</sup> Avenue SE the creek drops into a steep canyon that cuts through Vashon advance outwash deposits. Groundwater from this outwash probably flows into the creek and provides a source of summer baseflow.

The latest King County land cover data shows forest covering over 45 percent of the May Creek basin. Most of this is mixed conifer and deciduous forest, and is concentrated in the headwaters and along the creek canyons. 32 percent of the basin is covered with urban land uses, and impervious surfaces cover 18 percent of the basin area. The Honey Creek subwatershed has the highest density of urban land cover. New urban development is concentrated on the East Renton Plateau (south of May Valley). Low-density residential development is occurring rapidly in the Highlands area, north of May Valley. May Valley is covered by pastures, wetlands, and low-density rural development.

Table J-1 lists peak flow statistics for May Creek. Drainage areas above Coal Creek Parkway contribute about 53 percent of the total annual flow. Boren Creek, Honey Creek, and the North Fork are the largest tributaries. Existing development has increased peak flows at I-405 by over 50 percent. Future development is projected to increase flows by another 15 percent.

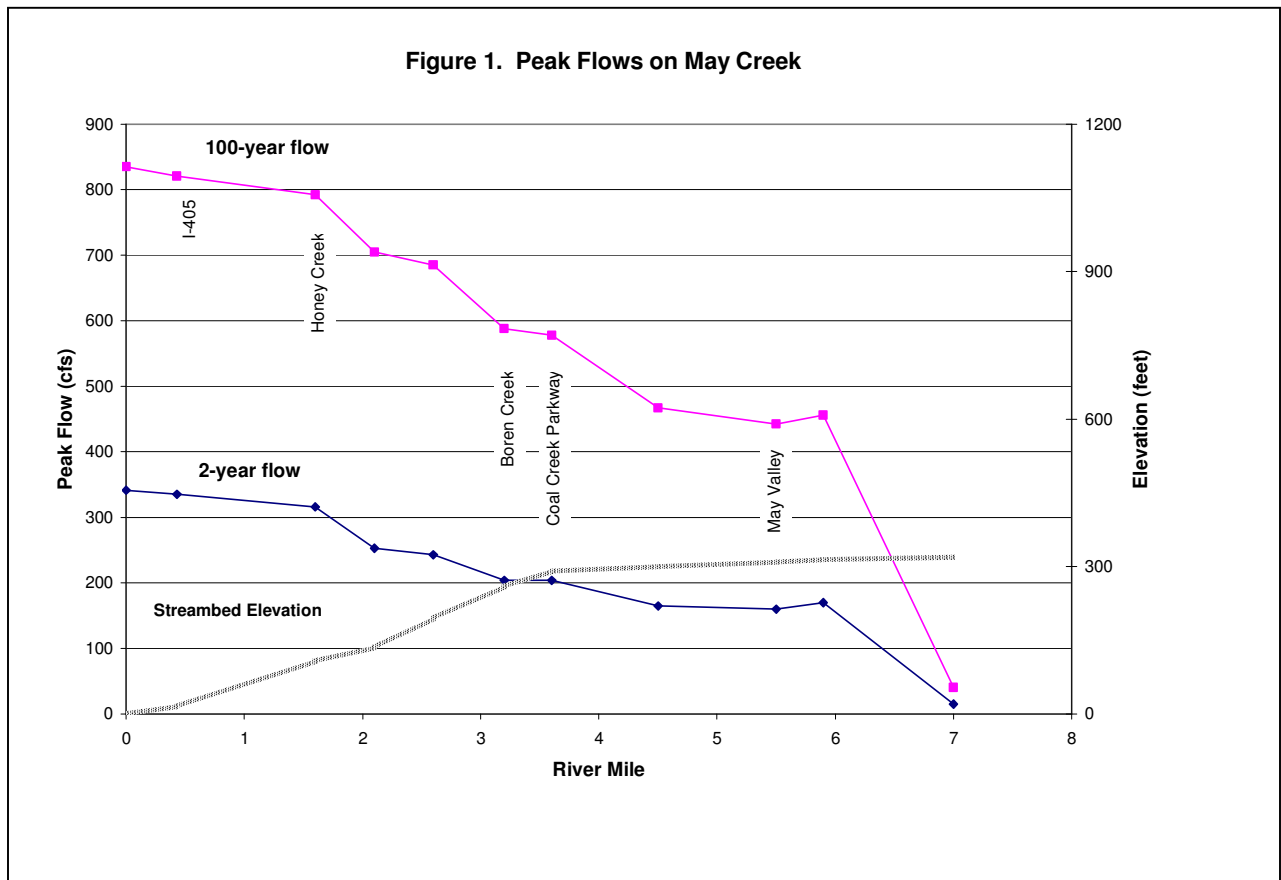


Figure J-1: Peak Flows on May Creek

Figure J-1 shows profiles of peak flows at various locations along the mainstem of May Creek. Streamflows increase rapidly between River Mile 7.0 and 5.9, as heavy runoff enters the system from the steep thin soils in the Highlands area. Peak flows actually decrease in May Valley (RM 4.5 – 7.0), illustrating the storage and attenuation provided by low gradient wetlands and floodplains. Below May Valley flows increase at the confluences with Boren Creek and Honey Creek. Peak flows at the head of May Creek Canyon (above Coal Creek Parkway) are 60 to 70 percent of the total at I-405.

HSPF modeling of the January 1990 event provides insight into the timing and distribution of runoff (Foster Wheeler Corporation, 1995). Tributaries peaked 8 to 14 hours earlier than the mainstem. Flows were delayed in May Valley, and peak flows in the May Creek Canyon were reduced by flood storage in the upstream wetlands and floodplains.

Lake Kathleen, May Valley, and to a lesser extent Lake Boren provide natural storage within the basin. Land use practices have reduced these storage functions by straightening channels, removing floodplain vegetation, and clearing beaver dams. Because of the low gradient and large storage capacity, flooding in May Valley is related more to the seasonal volume of runoff than to peak flow rates. Increased runoff from development in the East Renton Plateau and Highlands areas exacerbate the flooding problem. Detention of runoff from these areas is not likely to solve flooding issues in May Valley, since these measures delay but do not reduce runoff volumes.

Most of Newcastle lies in the May Creek watershed, including the Boren, Newport Hills, and Gypsy Creek basins. Channel erosion and sedimentation are major issues for the city in Newport Hills Creek and Gypsy Creek. The city operates a detention facility northwest of May Creek below Coal Creek Parkway, to treat runoff from an Issaquah School district facility. This pond will be expanded in the near future to accommodate runoff from future expansion of Coal Creek Parkway (Fritz Timm, City of Newcastle, personal communication).

The City of Renton covers the lower portion of the watershed, including most of the Honey Creek subbasin. Much of the Honey Creek drainage area was developed before modern stormwater standards were adopted, and there are opportunities upstream of SR 900 to improve stormwater management and reduce erosion problems in Honey Creek.

### **Cedar River**

The Cedar River drains a total area of 184 square miles above the USGS stream gage in Renton, including 62 square miles within the project study area. The upper 122 square miles drain into the City of Seattle's reservoirs and diversion above Landsburg. Seattle diverts an average of about 190 cfs from the river for water supply (King County Department of Public Works, 1993).

The Cedar River has cut deeply into the adjacent drift plains, creating steep bluffs that expose layers of glacial material. Springs often emerge where the bluffs intersect coarse glacial deposits. Glacial till soils predominate on the plateaus that lie above the bluffs. Runoff from these plateaus is typically conveyed to the Cedar River through tributary creeks that have eroded canyons into the steep valley walls. Glacial outwash terraces line the margins of the valley floor, and infiltrate much of the runoff from adjacent hill slopes. Alluvial floodplain soils cover the valley floor near the river.

Over 50 percent of the lower Cedar River basin remains as mixed conifer and deciduous forest. Approximately 28 percent of the lower basin is covered with urban or low-density development. High-density industrial and commercial uses in downtown Renton cover most of the alluvial fan at the mouth. Residential development is concentrated in the lower tributary areas (Maplewood Creek, Madsen Creek, Ginger Creek, Fairwood).

Table J-1 summarizes peak flow statistics at Renton, based on King County's HSPF modeling of 1989 land cover (King County Department of Public Works, 1993). Because of the low level of development in much of the upper watershed, existing peak flows are only about seven percent higher than would occur under forested conditions. Future development is projected to increase flood flows by another eight percent. Taylor Creek and Madsen Creek are the largest tributaries, followed by Peterson Creek, Fairwood/Molasses Creek, and Rock Creek.

Flood flows in the Cedar River are generated mostly from the upper watershed. The Masonry dam stores floodwaters and decreases the 100-year peak flow at Renton by 30 percent. Local runoff from Renton peaks early during storms, and shows up in the rising limb of Cedar River flood hydrographs. Hydrologic modeling conducted for the Lower Cedar River Basin and Nonpoint Pollution Action Plan (Metropolitan King County Council, 1997) found that detention of runoff from areas that discharge directly to the lower 17 miles of river has little impact on flood peaks and flow durations.

Wetlands, remnant channels, and floodplain forests stored and attenuated overbank flows and stormwater runoff under natural conditions. Many of these features have been filled, drained, or altered to facilitate other land uses. The Lower Cedar River Basin and Nonpoint Pollution Action

Plan therefore focuses on strategic removal of floodplain fill and levees to restore natural storage functions and remove structures from frequently flooded areas.

The Renton reach of the river is heavily urbanized, and is served by older stormwater systems that provide little detention or stormwater treatment. A major trunk line runs along 3<sup>rd</sup> Street and 4<sup>th</sup> Street and hooks into the I-405 drainage system to the Cedar River. This line serves a commercial and residential area with few flow control facilities. An abandoned gravel pit at 4<sup>th</sup> and Monroe provides opportunities for adding stormwater detention, infiltration, and treatment of runoff from this area.

### **Lake Washington Drainages**

Much of the land adjacent to I-405 drains directly to Lake Washington through urban storm drains and remnant stream channels. The Lakehurst area drains 1,300 acres between May Creek and Coal Creek, and lies mostly within the City of Bellevue. Approximately 68 percent of this area is covered with urban land uses, and 31 percent is impervious. Alderwood (glacial till) soils, with high runoff potential, cover 78 percent of the basin. Geologic maps show bands of outwash deposits in this area, so the till soils may be relatively thin or inaccurately mapped by the soil survey.

City of Bellevue drainage maps show several small streams in this area, including Lakehurst Creek. However, these streams have been heavily piped and channelized. Fish habitat surveys for the I-405 watershed characterization study found two remnant creek channels, both of which are completely piped from I-405 to Lake Washington (Buchanan, 2003).

The Kenndale area drains 440 acres of Lake Washington shoreline south of May Creek. This area is heavily urbanized, with over 90 percent of the land covered with urban uses. The total impervious area is 50 percent. Indianola soils, derived from recessional outwash material, cover 70 percent of the basin. Most of this area drains into Lake Washington through underground storm drains.

The North Renton area covers 1,370 acres north of the Cedar River, and drains through underground storm drains into a remnant section of Johns Creek before entering Lake Washington. Urban land uses, including much of downtown Renton, cover 94 percent of this area. Impervious surfaces cover 60 percent of the basin area. Most of the soils in this area are classified as modified/urban because of the high level of development. Under natural conditions most of the area would have been covered by alluvial and glacial till soils with moderate to high runoff potential. A terrace of Indianola and Ragnar recessional outwash soil crosses the northern portion of the basin upslope of I-405, and covers 23 percent of the total basin area.

### **Water Quality**

Tables J-2 and J-3 summarize data collected by King County and the Department of Ecology for Coal Creek and May Creek. Ecology's EIM database also contains water quality data for the lower Cedar River dating back to 1959. A discussion of these data is provided in the main body of the I-405 watershed characterization report.

**Table J-1. Peak Flow Estimates for Study Area Drainages**

Stream	Peak flow at I-405 (cfs)					
	2-year	5-year	10-year	25-year	50-year	100-year
<b>Coal Creek</b> <sup>1</sup>						
Future Buildout	269		387	448		542
<b>May Creek</b> <sup>2</sup>						
Forested Land Cover	223			480		636
Existing	341			670		835
Future Buildout	391			840		1059
<b>Cedar River</b> <sup>3</sup>						
Forested Land Cover	3500	4700	5800			
Existing	3700	4900	6100	8000	9700	11000
Future Buildout	4000	5200	6400			

<sup>1</sup>Northwest Hydraulic Consultants, Inc. 1997. Updates HSPF simulations from the 1987 Basin Plan to reflect constructed detention basins and preservation of forest in Cougar Mountain Regional Park. Historical and existing condition simulations were not performed.

<sup>2</sup>King County and the City of Renton, 1995. May Creek Current and Future Conditions Report. HSPF modeling.

<sup>3</sup>King County Department of Public Works, 1993. Cedar River Current and Future Conditions Report, HSPF modeling.



**Table J-2. Summary of King County Stream Monitoring Data for Coal Creek, 1997-2002**

<b>Parameter</b>	<b>Mean</b>	<b>Range</b>
Flow (cfs)	26.5	1.4 - 38
Dissolved Oxygen (mg/l)	11.0	9.2 – 13.1
Temperature (deg. C)	9.7	5.7 – 15.6
pH	7.6	6.8 – 8.1
Total Suspended Solids (mg/l)	140.1	5.4 - 1690
Total Phosphorus (mg/l)	0.121	0.018 – 0.390
Fecal Coliform (CFU/100ml)	560	24 - 20000
Cadmium (ug/l)	B.D.	B.D.
Chromium (ug/l)	0.58	B.D. – 1.10
Copper (ug/l)	1.83	0.10 – 4.45
Lead (ug/l)	0.20	B.D. – 0.50
Nickel (ug/l)	1.35	0.05 – 2.32
Zinc (ug/l)	1.68	0.15 – 3.0

B.D. = Below Detection Limit

Source: King County Streams Monitoring Program Website, 2003. Coal Creek Site 0442.  
<http://dnr.metrokc.gov/wlr/waterres/streams>.

**Table J-3. Comparison of King County and Ecology EIM data for Lower May Creek**

<b>Parameter</b>	<b>King County Streams Program<sup>1</sup> 1997-2002</b>		<b>Ecology EIM<sup>2</sup>, 2001-02 Range</b>
	<b>Mean</b>	<b>Range</b>	
Flow (cfs)	37.2	2.9 – 72.0	
Dissolved Oxygen (mg/l)	10.9	9.2 – 12.5	
Temperature (deg. C)	9.3	4.6 – 15.7	

pH	7.4	6.9 – 7.8	
Total Susp. Solids (mg/l)	81.7	11.4 - 608	
Total Phosphorus (mg/l)	0.122	0.039 – 0.366	
Fecal Coliform (CFU/100ml)	738	94 - 4800	
Cadmium (ug/l)	B.D.	B.D.	
Chromium (ug/l)	0.38	B.D. – 0.59	0.8
Copper (ug/l)	1.42	0.10 – 3.94	0.74 – 2.32
Lead (ug/l)	0.18	B.D. – 0.50	0.05 – 0.285
Nickel (ug/l)	0.79	0.05 – 1.20	
Zinc (ug/l)	3.67	0.15 – 18.7	1.8 – 12.4

B.D. = Below Detection Limit

<sup>1</sup>King County Streams Monitoring Program Website, 2003. May Creek Site 0400.

<sup>2</sup>Wa. State Department of Ecology EIM Website, 2003. Rainy Season Samples only (Nov-May).